Search for the SM Higgs boson in the fully hadronic di-τ final state

with the ATLAS Experiment at LHC [ATLAS-CONF-2012-160]

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$H \rightarrow \tau_{HAD} \nu \tau_{HAD} \nu$

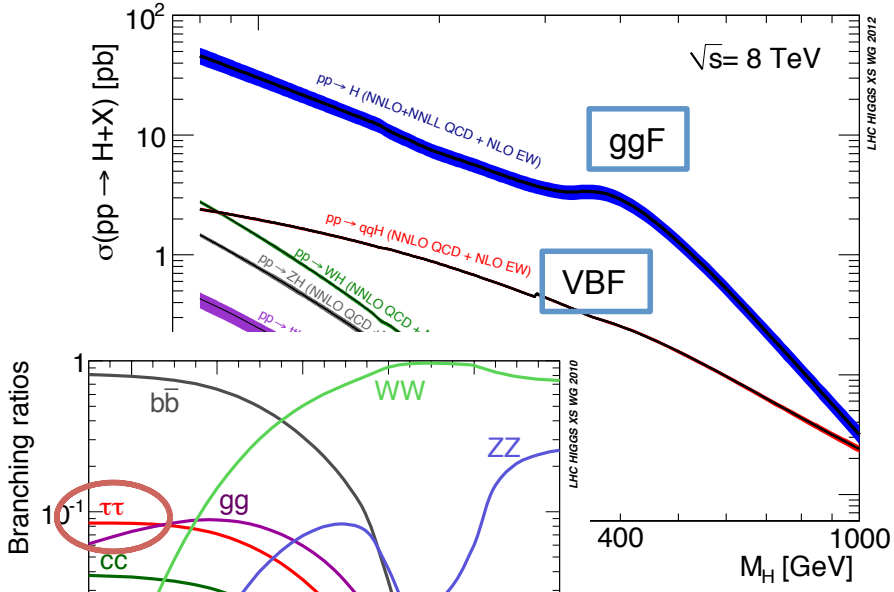
THE MEASUREMENT OF THE FERMIONIC COUPLING OF THE NEWLY OBSERVED RESONANCE IS CRUCIAL FOR CLAIMING THE DISCOVERY OF THE HIGGS BOSON

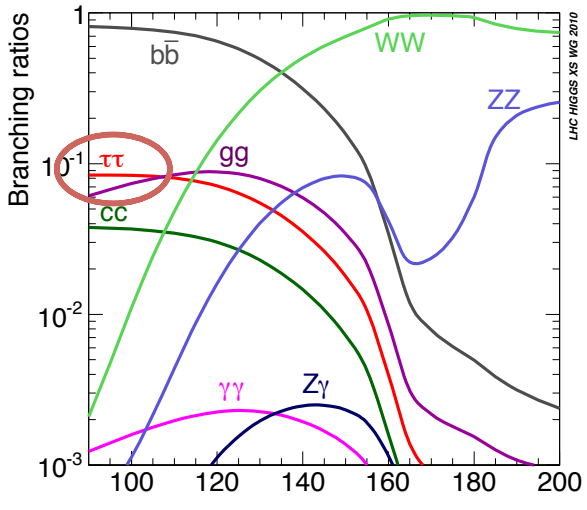
Main features of this search:

1. τ_{had} = visible products of the τ hadronic decay
2. cut-based selection optimized for gluon fusion (ggF) and vector boson fusion (VBF)
3. high BR($H \rightarrow \tau\tau \rightarrow hh$)
4. $Z \rightarrow \tau\tau$ irreducible bkg
5. multi-jet events biggest but reducible bkg (2 mis-id'ed jets)

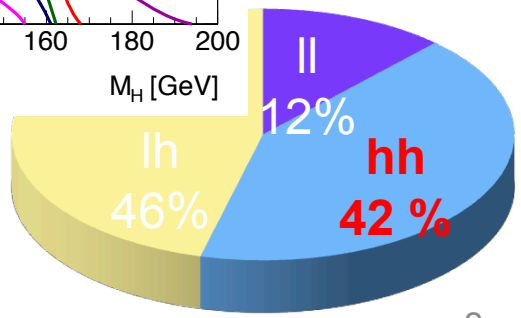
Critical points:

1. double τ_{had} trigger
2. multi-jets modelling





arXiv:1101.0593

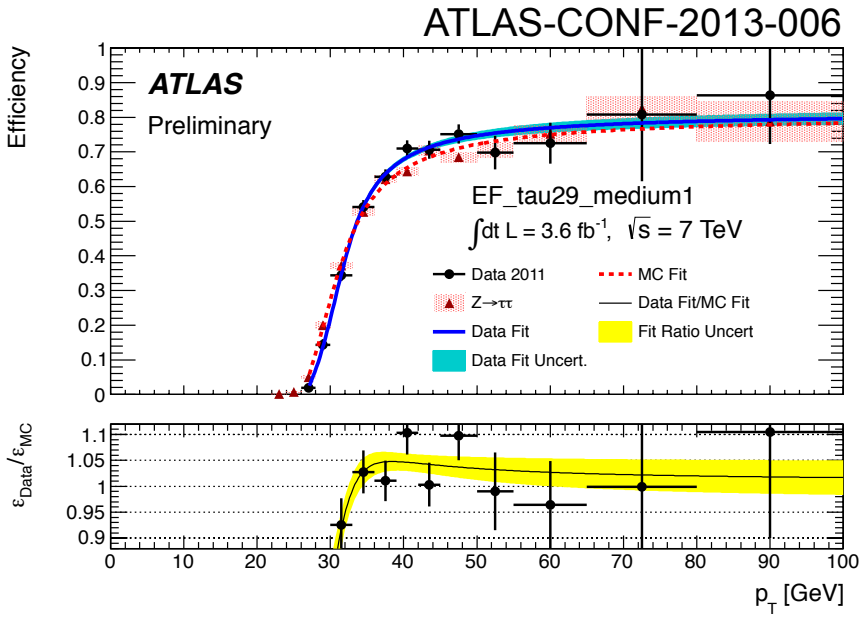


DOUBLE τ_{HAD} TRIGGER

At trigger level:

1. Poor discrimination between τ_{had} and light-jets from quarks/gluon
2. High p_T thresholds to limit trigger rate
3. Trigger p_T drive the offline p_T thresholds
4. τ-id to improve signal acceptance and light-jets rejection

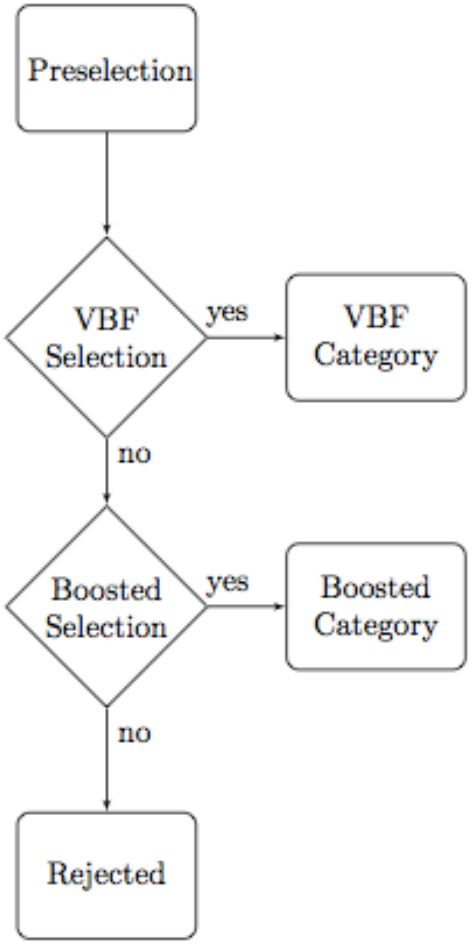
	Leading τ_{had} p_T	Sub-leading τ_{had} p_T
L1 Trigger	15	11
EF Trigger	29	20
Offline	40	25



Single-tau trigger eff wrt offline selection

2-tau trigger ≈ (single-tau trigger)^2

EVENT SELECTION



1. **Preselection**: τ-pair selection
   - No muons or electrons
   - 2 id'ed taus with p_T>40,25 GeV, 0.8<ΔR(τ,τ)<2.8, $\Delta\eta(\tau,\tau)$<1.5
2. **VBF**: optimized for VBF production mode
   - ≥2 jets with p_T>50,30 GeV, $\eta_{j1}\times\eta_{j2}$<0, $\Delta\eta_{jj}$>2.6, m_{jj}>350 GeV
   - E_T^{miss}> 20 GeV, pointing in between the taus
3. **Boosted**: optimized for the gluon fusion production with one boosting jet
   - ≥1 jet with p_T>70 GeV
   - 0.8<ΔR(τ,τ)<1.9
   - E_T^{miss}> 20 GeV, pointing in between the taus

BACKGROUND ESTIMATION

	$Z \to \tau\tau$	Multi-jets	Others* ($W \to \tau\nu$+j, top)
Yield	Fit of the 2D track multiplicity distribution of the 2 selected tau		Monte Carlo prediction
Shape	Embedded $Z \to \mu\mu$ events	Opposite-Signed (OS) events where taus fail the τ-id	

* Very little yield

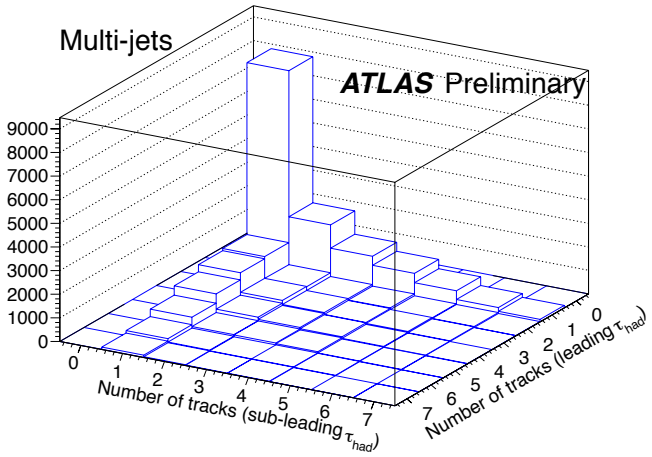
= Data driven methods

= τ-id + trigger efficiency measured in data (tag-and-probe with Z and W)

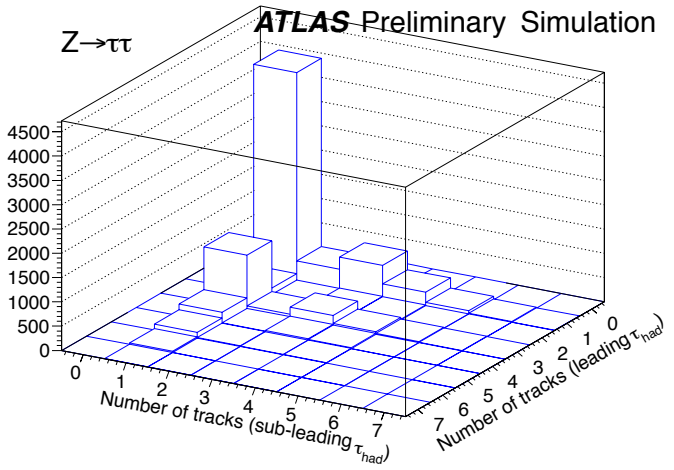
= τ-mis-id + trigger efficiency measured in data (tag-and-probe with W)

BKG NORMALIZATION: 2D #TRK FIT

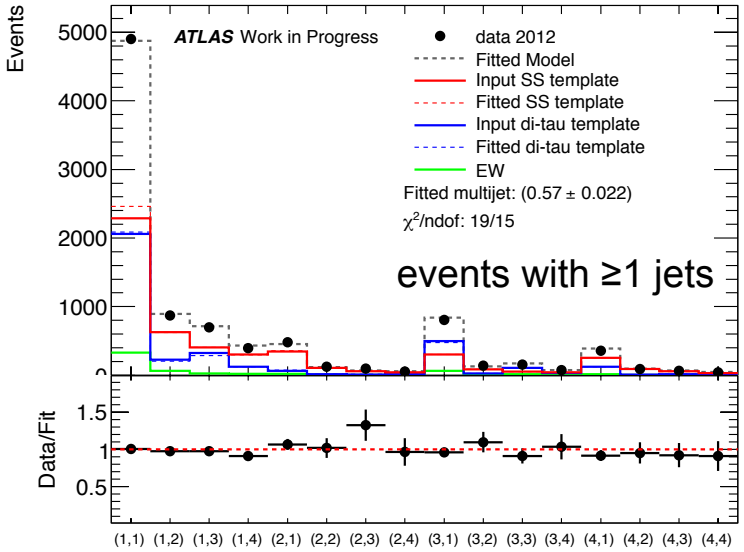
Multi-jet template (SS)



di-τ template (Z MC)



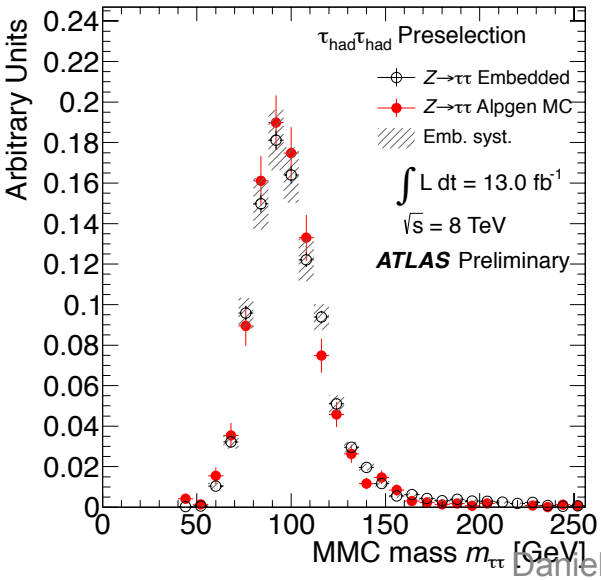
1. #trk distribution can discriminate di-τ (Z/H) from multijets events
2. Fit with 1 free parameter, f_{QCD}
3. $f_{di\text{-}\tau} = 1 - f_{QCD} - f_{others}$
4. Z fitted at early stage of event selection to avoid signal contamination
5. Multi-jets fitted at the end of the event selection

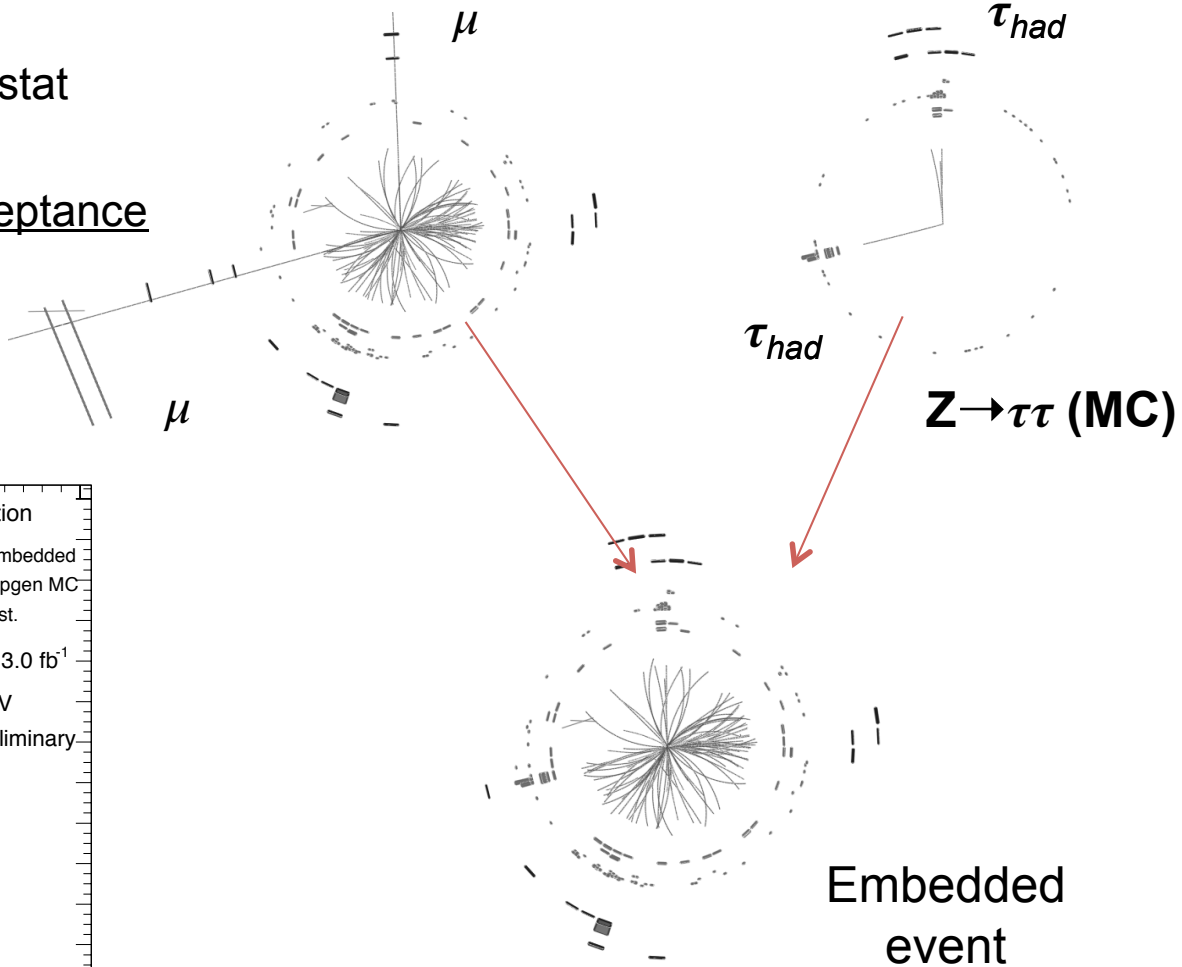


Z+JETS MODELING

$Z \to \mu\mu$ (data):

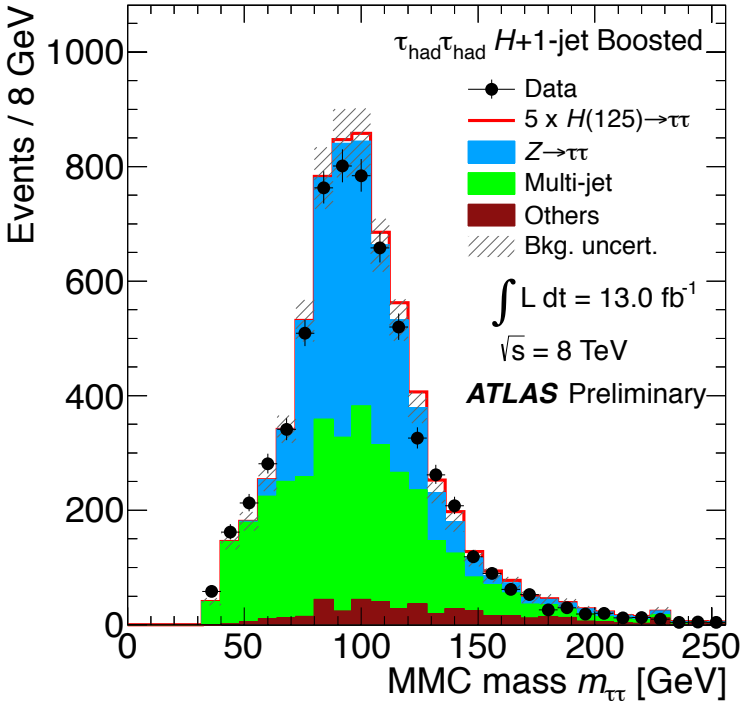
1. high purity, high stat
2. signal free
3. <u>correct VBF acceptance</u>





MULTI-JETS MODELING

1. Very difficult to model events with 2 mis-id'ed jets (no CR available in the analysis)
2. OS(f,f) events: OS events with taus faling τ-id
3. Modeling events with taus passing τ-id with OS(f,f) requires a reweighting because the mis-id eff depends on the kinematics
4. Weight = $[\Delta R(\tau_1,\tau_2), p_{T,\tau 1}, p_{T,\tau 2}, \eta_{\tau 1}, \eta_{\tau 2}] \times [E_T^{miss}, \#vertices]$



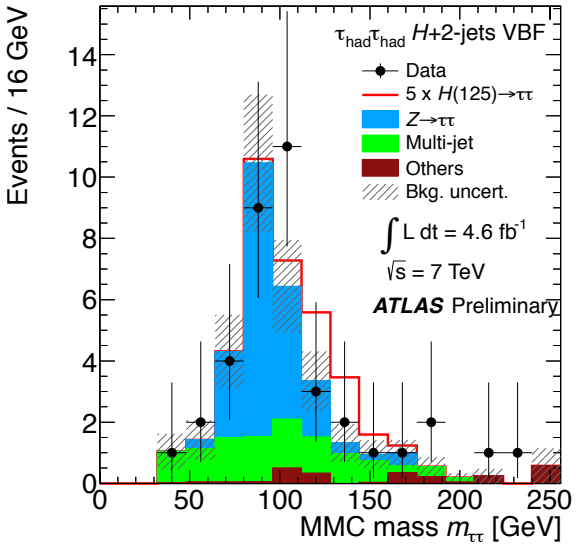
Mass plots of events with ≥1 jets

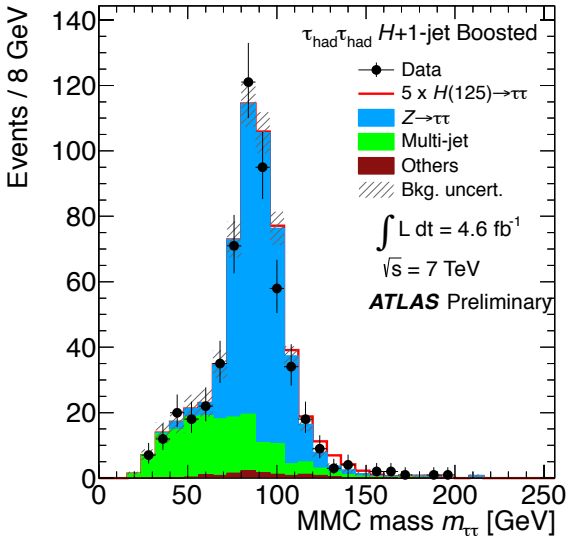
OBSERVED MASS PLOTS

VBF

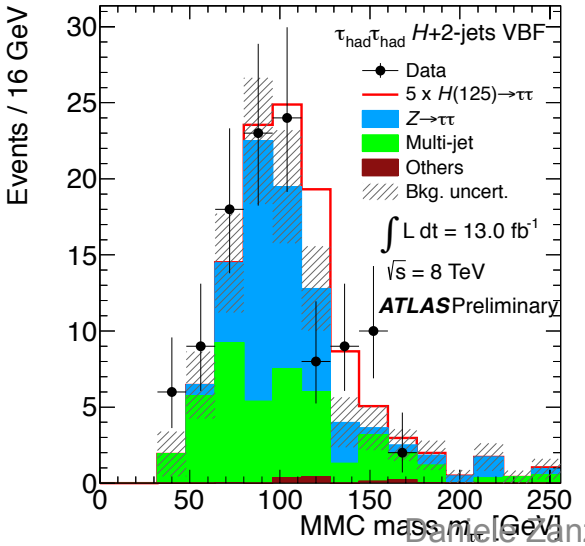
Boosted

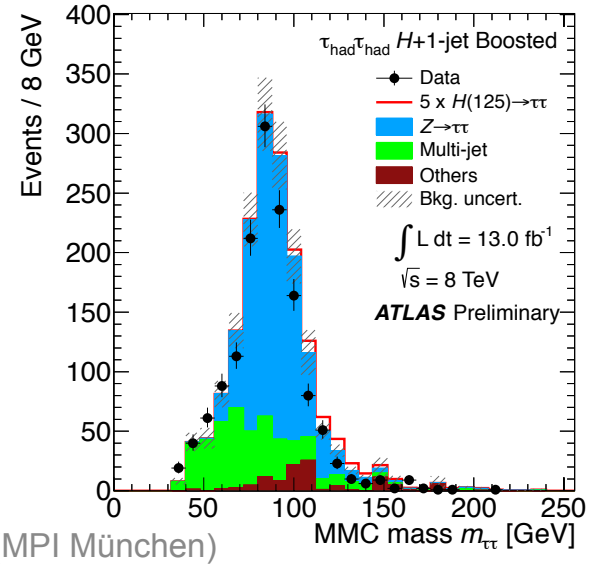
2011 data
4.6 fb^{-1}





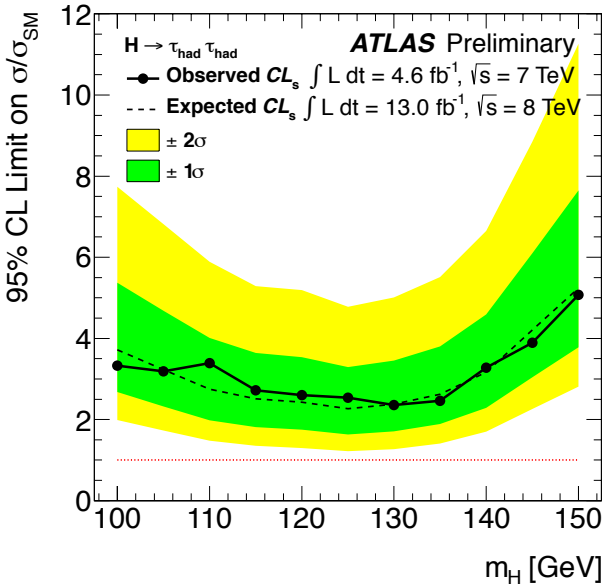
2012 data
13 fb^{-1}

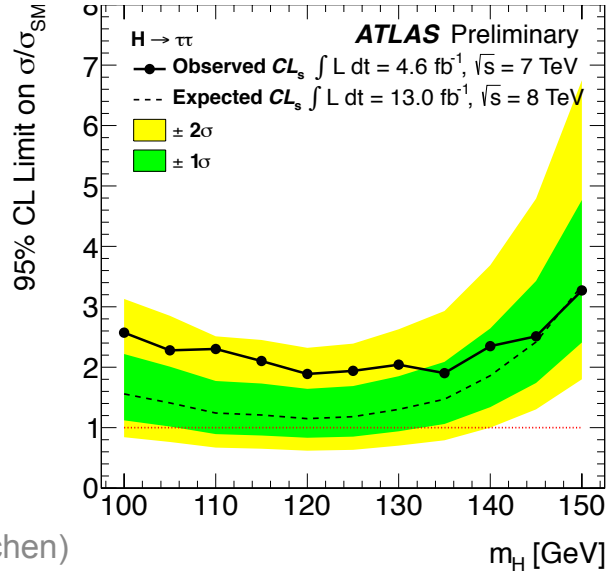




EXCLUSION LIMITS

1. Out of the 3 $\tau\tau$ final states, the $\tau_{had}\tau_{had}$ is the second most sensitive
2. For the 125 GeV mass point, the observed(expected) 95% CL upper limits are:
   H→$\tau_{had}\tau_{had}$: 2.5(2.3)
   H→$\tau\tau$: 1.9(1.2)
3. The observed(expected) significance for deviations from the background-only hypothesis at the 125 GeV is 1.1(1.7)σ
4. The fitted signal strength is 0.7±0.7 times the prediction for the SM Higgs boson with the mass of 125 GeV





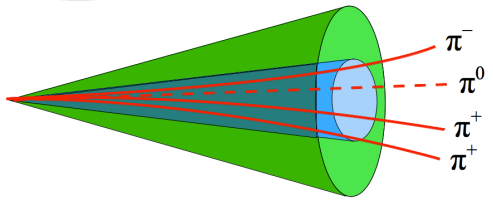
SUMMARY

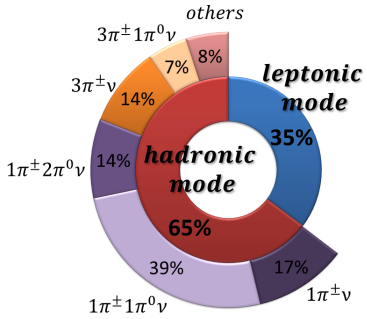
1. The $\tau_{had}\tau_{had}$ is crucial for the sensitivity of the combined $H \rightarrow \tau\tau$ search
2. No significant excess observed, but the sensitivity is still not enough to probe the Higgs coupling to fermions
3. 7 fb^{-1} of 2012 data still to be analyzed

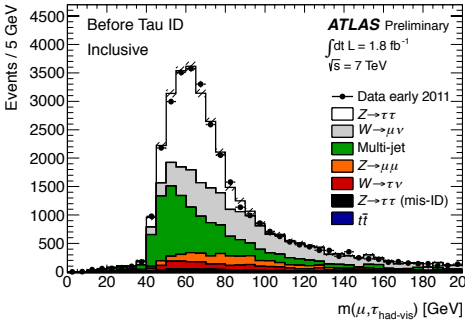
BACKUP SLIDES

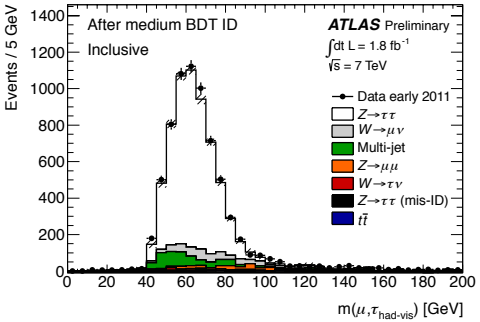
TAU IDENTIFICATION

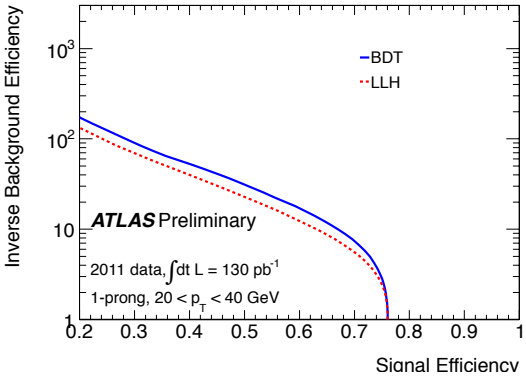
ATLAS-CONF-2012-142

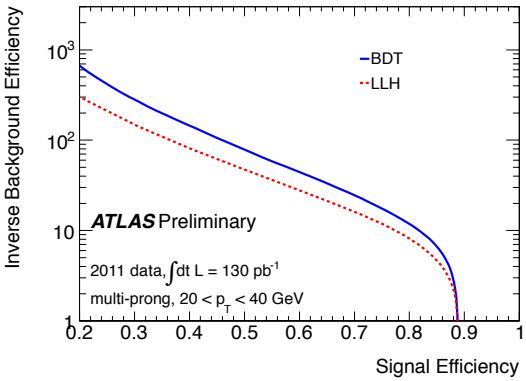


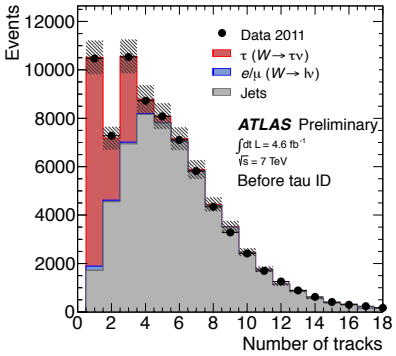


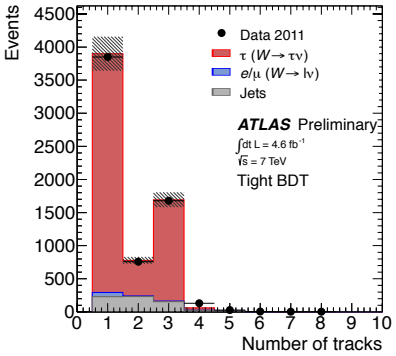


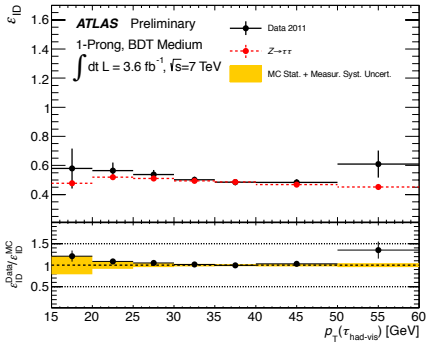


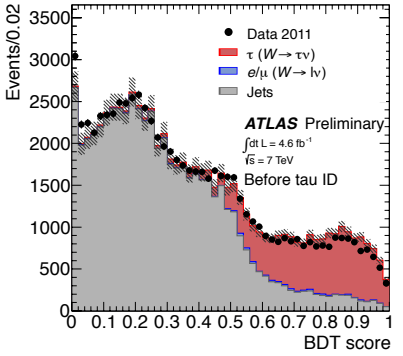












EXCLUSION LIMITS